Visible Light Communication in the Dark
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Problem: What If the Light Is Off?

Why Visible Light? Operating on visible light band, Visible Light Communication (VLC) holds a great potential to solve the spectrum crunch, complementing RF technologies, such as Wi-Fi.

Problem: The VLC link ceases when the lights are off

VLC in the dark: A new VLC primitive

- Always-on. Extend the application scenario of VLC to 24/7: the VLC link sustains even if the light source appears dark
- Imperceptible. VLC up-link for mobile devices. The minimum luminance shift incurred by the LED is 0.09 lx
- Energy-efficient. The ultra-low energy consumption makes it appealing to Internet of Things (IoT) devices, given the tight energy budget. 46.8 µW power consumption

How to reduce the duty cycle?

- Narrow the ON time.
  ✓ Set ON time to its minimum, the physical constraint

  - Turn-on time of the LED
  - Rise- and fall-time limits of the switching circuitry
  - Bandwidth of the photodiodes

- Widen the period time (ON time + OFF time).
  ? Trade-off

  - Small: bright light
  - Large: low data rate and flickering effect

Implementation: Make the Switching Fast

Design: Decrease the Duty Cycle

We do not completely switch off the light; instead, we reduce its luminance to “negligible” but still maintain its ability of communication. We make the LED light appear off by decreasing its flashing duty cycle.

Reducing the peak intensity will curtail the communication distance according to the inverse-square law.

Results: Illuminance, Power, and Data Rate

The illuminance gradually drops to the ambient light level with the increase of the period time. The minimum illuminance shift incurred by the LED is only 0.09 lx. Imperceptible to human eyes in the day.

The power is proportional to the duty cycle. In our testbed, the power of the LED of VLC in the dark can reach as low as 46.8 µW.

Discussion: Throughput and Network

- Boosting the link rate. Pulse Position Modulation (PPM) can improve the data rate by one order.
- Supporting longer distance. Try more sensitive photodiodes.
- Building network of VLC in the dark. Design the MAC protocol that is suitable for the existence of multiple links.
- Ambient light aware adaptation. Adapt the data rate and illuminance according to the ambient light.
- Potential application. Near field communication and IoT devices.

References